STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF FACILITIES CONSTRUCTION
OFFICE OF TRANSPORTATION LABORATORY

EVALUATION OF MOLDS USED TO FABRICATE ASPHALT CONCRETE TEST SPECIMENS

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16. ABSTRACT

This study was undertaken to determine the effect of texture and diameter of a fabrication mold on the stabilometer value (using the Hveem stabilometer). Fabrication molds were tested from the states of Washington, Colorado, and California.

This study revealed that surface texture of the inside of a mold has an insignificant effect on the Hveem stability.

It also revealed that the inside diameter of a mold does not have a significant effect on Hveem stability unless the diameter exceeds the diameter of the stabilometer throat.

Specifications for fabrication molds were prepared.

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second 1/s)
	gallons per minute (gal/min)	.06309	litres per second (1/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi$\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ (MPa$\sqrt{m}$)
	pounds per square inch square root inch (psi$\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ (KPa$\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

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I. INTRODUCTION

Because of questions raised in three states (California, Washington, and Colorado), concerning the fabrication of AC test specimens for Hveem stability determination, a cursory study of the molds used for fabrication of these test specimens was completed by TransLab in 1985. The effect of the inside surface texture was examined. This led to the same conclusion that had been reached in a similar study in 1956; the inside surface texture did not significantly effect the test results. However, it was felt that a more in-depth study was needed to test for variation in mold diameter, and to include molds from the states of Washington and Colorado in the testing. Therefore, in 1986, a more comprehensive research study was undertaken.

II. BACKGROUND

Variations occurring in the Hveem stability test values have periodically been suspected to be caused by the fabrication mold, incorrect testing, compaction temperature, incorrect compaction techniques, incorrect calibration of the press, compactor or stabilometer, asphalt content, aggregate grading or physical properties, etc. All of these potential problem areas must be analyzed when questionable test results are observed. Although the test procedures are written to assure that any given one is not responsible, the physical dimensions and inside surface requirements for the fabrication mold (Figure 1) have not been precisely identified. As a consequence, the inside surface texture of the mold has occasionally been the prime

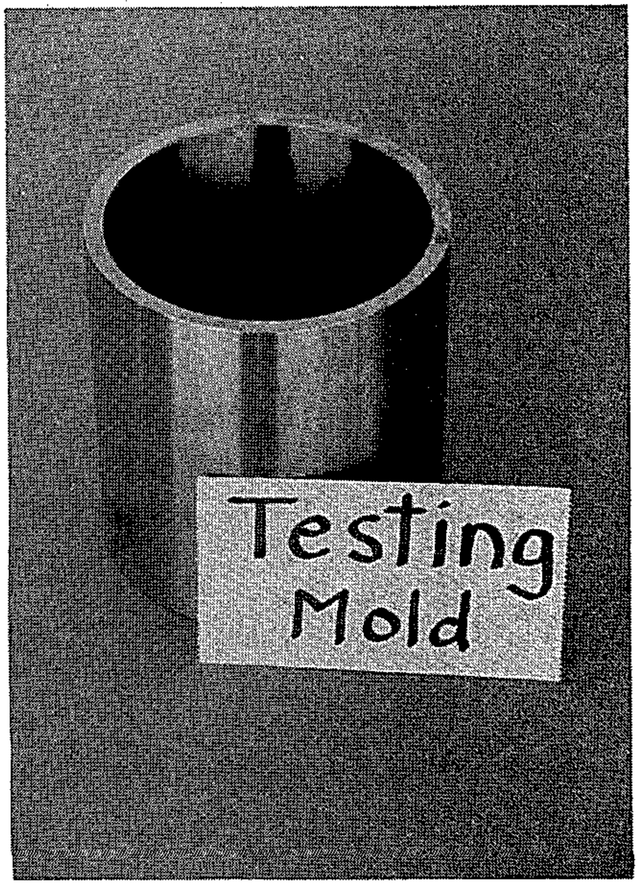


FIGURE 1

FABRICATION TEST MOLD

suspect when attempting to determine the reason for questionable test results. As early as 1956, interest in the effect of surface texture triggered a study by the California DOT of this physical property. The study concluded that inside surface texture had a negligible effect on the Hveem stabilometer value. However, other molds used in soils testing (R-value) were deliberately given a rougher texture (a slight rifling) to prevent the compacted samples from dropping from the mold after compaction. Previous to this, the molds had a smooth glass-like texture. No problem was experienced retaining samples of bituminous mix in these smooth textured molds; thus, it was felt that rough molds specified for soils testing or R-value work that became worn and smooth could still be used for fabricating bituminous mixtures. In 1956, the smoothness or roughness was determined by comparing coupons cut out of new molds with the General Electric Surface Roughness Scale, Cat. #342. One coupon had a roughness of 250 micro inches and represented the texture of the R-value molds, while another coupon having a value of 32 micro inches represented the smoother molds then used for testing bituminous mixtures. The texture of the molds was then determined by rubbing the thumb over the coupon and then over the inside of a mold, thereby resulting in the texture of the mold being classified entirely by feel. This procedure has since been used for acceptance of new molds and for eliminating, for R-value testing, any mold that approached or was considered equal to 32 micro inches. These smooth molds have been stamped or color coded and used only for fabricating bituminous mixtures.

The 1956 study of these molds (both smooth and rough textured) was confined to only bituminous mixtures because the rough texture was an absolute <u>must</u> for R-value testing.

The results, as mentioned earlier, indicated essentially no difference in test values between molds; however, no attention was given to the mold diameter during this period.

In 1982, newer personnel in the California DOT began questioning the physical characteristics of the molds (inside diameter, texture and wall thickness) due to a series of erratic test results. However, the subject wasn't given a great deal of attention until, in 1984, Robert Warbarton, Materials Engineer with the Wyoming Highway Department, contacted us and brought to our attention problems of a similar nature that had been reported by A. J. Peters, Materials Engineer of the State of Washington, and Stuart C. Tapp, Staff Materials Engineer of the State of Colorado. Both of these individuals suspected that mold surface texture influenced stability. Mr. Warbarton, as Chairman of AASHTO Subcommitte on Materials Technical Section 2.c, designated Mr. R. A. Forsyth as Task Force Chairman of a committee to investigate on a nationwide basis the problem of molds used for fabrication. This led us to the 1985 cursory study by TransLab and then to the research which is the subject of this report.

III. OBSERVATIONS AND CONCLUSIONS

1. The inside surface texture of fabrication molds tested in this study had an insignificant effect on the Hveem stabilometer value.

2. One of the fabrication molds received from the State of Washington had an inside diameter that exceeded the diameter of the throat of the Hveem stabilometer;

samples prepared with this mold were damaged when extruded from the mold into the stabilometer and a loss in stability was recorded. Thus, the inside diameter of a fabrication mold must not exceed the throat diameter of the Hveem stabilometer.

3. Variations in the diameter, roundness, wall thickness, and inside wall surface texture of the California fabrication molds had no significant or predictable effect on (Hveem) stability, (Hveem) cohesion, or resilient modulus.

4. The fabrication molds received from the State of Colorado were somewhat smooth, but relative to the diameter of the stabilometer throat, had inside diameters within tolorable limits. These molds had very little effect on test results.

IV. RECOMMENDATIONS

The following recommendations are made pertaining to fabrication molds used to prepare samples for various bituminous mix tests:

1. The inside diameter of new molds should be 4.000 $\pm$ 0.010 inches, inclusive.

2. Molds with pits or gouges deeper than 0.0625 inches on the inside surface produce samples which may provide erroneous test results.

3. The molds should be constructed of stainless steel.

4. Molds that become larger than 4.020 inches in diameter should be discarded.

5. A new specification for fabrication molds should be written (see summary).

V. IMPLEMENTATION

Molds used for California Test 303 and 304 shall have the inside diameter and surface roughness specified. These test methods will be rewritten to include the appropriate specifications for the mold. Copies of this report shall be transmitted to Robert G. Warbarton, P. E., Chairman, AASHTO Subcommittee on Materials Technical Section 2.c, for distribution as he feels necessary.

When calibrating and checking AC test equipment, molds will be checked for compliance with the requirements to be included in revised test procedures.

VI. DISCUSSION

A. General

In this study, two objectives were outlined in the work plan.

1. Determine the effect of mold diameter, roundness, and inside surface texture on AC stability using mixes containing 1/2 and 3/4 inch maximum aggregate.

2. Establish specifications for the molds and a mold certification program.

The objectives, in general, were satisfied. The inside surface texture and roundness had minimal effect on test results. Also, the inside diameter was not a factor until it exceeded the throat diameter of the stabilometer.

B. Surface Texture (Roughness)

It was difficult to gauge or identify the inside mold surface texture (referred to as surface texture hereafter) and, thus, it was decided to use the commercial services of the Pruett Manufacturing Company located in Sacramento. Pruett, using the Micro Metrocal Profilometer, established a scale of "0" to "300" for surface texture ("0" represents a smooth glass-like finish and 300 was considered a rough texture). The cost per test per mold was $10.00. All the molds used for fabrication of specimens in this study were tested. The results are shown in Table 1.

In order to obtain molds for testing which represented extremes in diameter and surface texture, new mold stock was machined outside the limits of those in routine use by Caltrans. However, the extreme upper value for surface texture used for this study complied in roughness with Caltrans' current specification for a new mold, and represented the upper limit of the scale.

The terms used to classify the Washington and Colorado molds (good, poor) were terms chosen by those particular states.

TABLE 1

Mold Texture Measurements

State	Inside Diameter (in.)	Texture	
		Measurements*	Classification
California	3.990	18	Smooth
	3.990	263	Rough
	4.020	25	Smooth
	4.020	260	Rough
Washington	4.000	70	Good
	4.051	125	Poor
Colorado	4.004	40	Good
	4.012	40	Poor

* Texture measurement was determined using the Micro Metrocal Profilometer.

C. Mold Roundness

It was found that not only were most new and used molds out of round to some degree (Table 2), but the throat of the stabilometer was also out of round (Table 3). Out of roundness, however, did not appear to have any effect on test results in this study as long as the maximum inside mold diameter was smaller than the minimum throat diameter of the stabilometer.

D. Wall Thickness

Another physical property noted but not specifically studied was the mold wall thickness. All of the molds used in this study had a wall thickness that varied from 0.226 to 0.256 inches (Table 2).

Arbitrarily selecting 10 molds from the California supply of used molds revealed a range of wall thickness varying from 0.243 to 0.249 inches. Based on all the wall thickness measurements, it would appear that a wall thickness of 0.240 $\pm$ 0.020 inches could be specified without causing any mold production or materials testing problems.

E. Stabilometer Throat Diameter

The throat diameter of the stabilometer controls the maximum permissible diameter that a specimen may have in order to avoid damage to the specimen when it is inserted into the stabilometer. It was found, after measuring the throat of seven different stabilometers, (Table 3), that the smallest diameter was 4.033 inches. Realizing still

TABLE 2

Mold Diameter Measurements

State	Mold Identification	DIAMETER* (in.)						Wall Thickness (in.) (Avg)
		Inside			Outside			
		#1	#2	Avg	#1	#2	Avg	
California (Used)	1**	4.005	4.003	4.004	4.489	4.492	4.491	.243
	2	4.000	4.000	4.000	4.482	4.490	4.486	.243
	3	4.006	4.000	4.003	4.495	4.490	4.493	.245
	4	4.001	4.002	4.002	4.490	4.488	4.489	.244
	5	4.002	4.002	4.002	4.489	4.488	4.489	.243
	6	3.999	3.997	3.998	4.492	4.494	4.493	.248
	7	3.996	3.998	3.997	4.488	4.489	4.489	.246
	8	3.999	3.998	3.999	4.494	4.495	4.495	.248
	9	3.995	3.996	3.996	4.494	4.493	4.494	.249
	10	4.006	4.004	4.005	4.489	4.491	4.490	.243
Washington	Good	4.000	4.000	4.000	4.506	4.516	4.511	.256
	Poor	4.054	4.048	4.051	4.505	4.505	4.505	.228
Colorado	Good	4.004	4.004	4.004	4.487	4.489	4.488	.242
	Poor	4.012	4.013	4.012	4.491	4.492	4.492	.240
California (Machined)	Rough	4.020	4.020	4.020	4.480	4.481	4.481	.230
	Rough	3.990	3.990	3.990	4.440	4.443	4.442	.226
	Smooth	4.020	4.020	4.020	4.481	4.479	4.480	.230
	Smooth	3.990	3.990	3.990	4.473	4.474	4.474	.242

* Measurement #2 taken at 90° to #1.
** Random Selection

TABLE 3

Stabilometer Throat Measurements

Stabilometer		Throat Diameter (in.)	
Location	Identification	#1	#2
TransLab	L-1 L-6 R-1	4.045 4.053 4.057	4.044 4.052 4.050
District 02 Lab	1 2 3 4	4.044 4.040 4.048 4.048	4.041 4.033 4.059 4.046

* Measurement #2 taken at 90° to #1.

smaller throat diameters may exist, it was decided to use 4.020 inches as the maximum diameter of a test specimen. A diameter of 3.990 inches was arbitrarily selected as the minimum diameter for a test specimen.

F. Test Results

All testing was conducted using Teichert Perkins aggregate with 1/2 and 3/4 inch maximum medium gradings. Information on these two mixes used is shown in Table 4. The asphalt used was Conoco's AR1000 and Chevron's AR4000 (absolute viscosities, after the rolling thin film oven test, at 140°F, were 868 and 4278, respectively). Specimens were fabricated in the various molds using the California kneading compactor. The test results are presented in Tables A1-A12 (in the Appendix) and compared in Figures 2-7. All tests were performed in triplicate except for the resilient modulus (M_r) tests where a fourth sample was prepared and tested for each series. The M_r test is usually performed (by Caltrans) on a sample prior to testing for stability. However, this sequence was not used in this study to avoid any controversy that may arise from testing a sample for stability that was allowed to set unconfined for up to 24 hours (sample must be cooled to room temperature before conducting M_r test). Thus, one sample per series was prepared specifically for M_r testing. However, other tests (stability and cohesion) were also run on this same sample after it was tested for M_r (these results were not averaged with other tests.)

1. California Molds

The machined California molds represent extremes in values for diameter and surface texture (considering molds used

TABLE 4

TEICHERT PERKINS AGGREGATE

1/2" MAXIMUM MEDIUM TYPE B[3]

Sieve	% Passing	Specification Tolerance		
3/4	100	100	Kc^1	= 1.2
1/2	100	95-100	Kf^1	= 1.2
3/8	89	80-95	Km^1	= 1.2
4	60	54-71		
8	46	38-54	Specific Gravity_c	= 2.74
16	33			
30	23	17-32	Specific Gravity_f	= 2.78
50	14			
100	9		Specific $\text{Gravity}_{avg.}$	= 2.77
200	6	3-8		
			Sand Equivalent Value[2]	= 79

Optimum Bitumen Content (O.B.C.) = 5.5%

3/4" MAXIMUM MEDIUM TYPE B[3]

Sieve	% Passing	Specification Tolerance		
1	100	100	Kc^1	= 1.1
3/4	100	95-100	Kf^1	= 1.2
1/2	84		Km^1	= 1.2
3/8	73	65-80		
4	55	44-59	Specific Gravity_c	= 2.76
8	38	31-45		
16	27		Specific Gravity_f	= 2.78
30	19	13-26		
50	12		Specific $\text{Gravity}_{avg.}$	= 2.77
100	8			
200	5	3-8	Sand Equivalent Value[2]	= 82

Optimum Bitumen Content (O.B.C.) = 5.0%

Notes:
1. Specification Requirement - 1.7 maximum
2. Specification Requirement - 45 minimum
3. 1984 California Standard Specifications

routinely by Caltrans). The test data obtained from these molds was, therefore, first plotted separately from the data obtained using the Washington and Colorado molds. This data is presented in Figures 2, 3, and 4 (plotted from Tables A-5 through A-12) and overall it reveals that test values were not significantly influenced by either inside mold diameters smaller than the stabilometer throat or by surface texture.

When comparing data representing the two grades of asphalt (AR-4000 vs. AR-1000), the values were influenced by the viscosity, but when comparing the results within a given viscosity (e.g. AR-4000 or AR-1000), the results did not vary significantly.

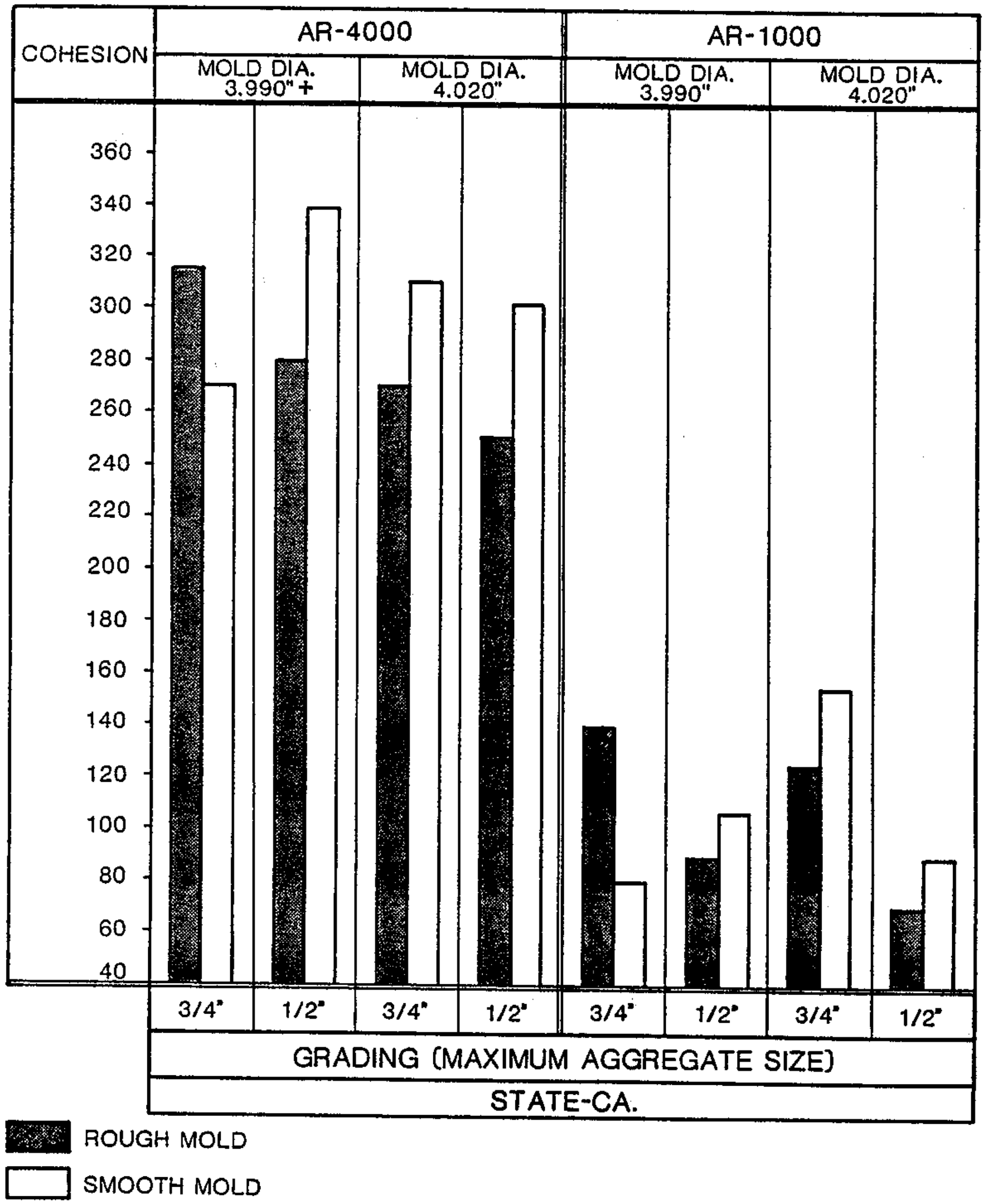
In Figures 5, 6, and 7, test data that was obtained using molds from all three states is presented. In looking at these figures and Tables A-1 thru A-12, certain facts were revealed. They are presented below under Washington Molds and Colorado Molds.

2. Washington Molds

The average surface texture was 70 for the mold classified as "good" and 125 for the "poor" mold (all measurements taken using the Micro Metrocal Profilometer). The surface texture of the machined California molds ranged from 262 for the rough to 17 for the smooth. Thus, both molds from Washington had a surface texture, relatively speaking, within the extremes prepared for testing.

The diameter of the two Washington molds, however, varied considerably. The following remarks pertain to each mold:

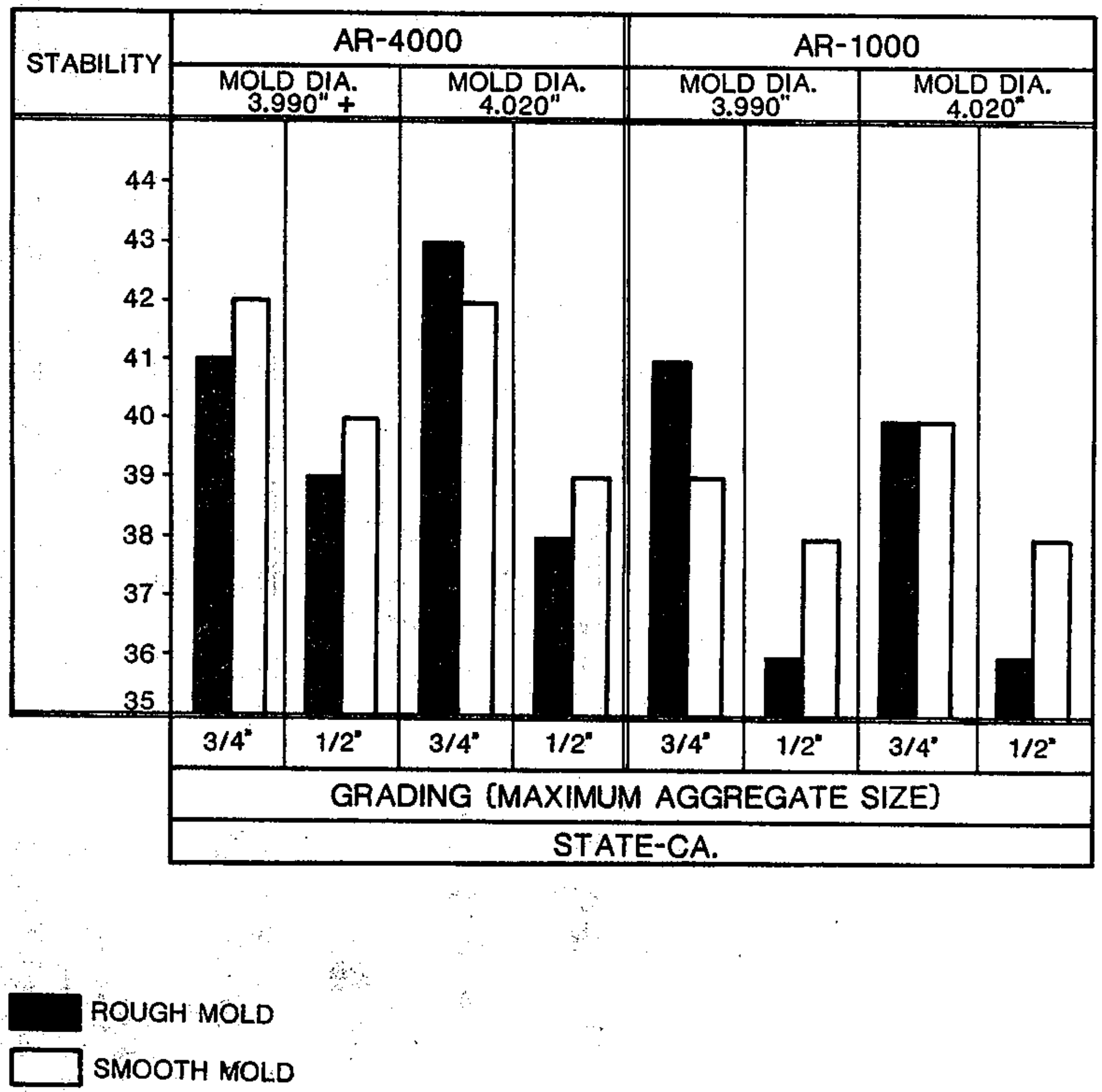
COHESION
CALIFORNIA TEST 306



\+ ALL DIAMETERS ARE INSIDE DIAMETERS

FIGURE 2

STABILITY
CALIFORNIA TEST 366



\+ ALL DIAMETERS ARE INSIDE DIAMETERS

FIGURE 3

M_r

CHEVRON METHOD

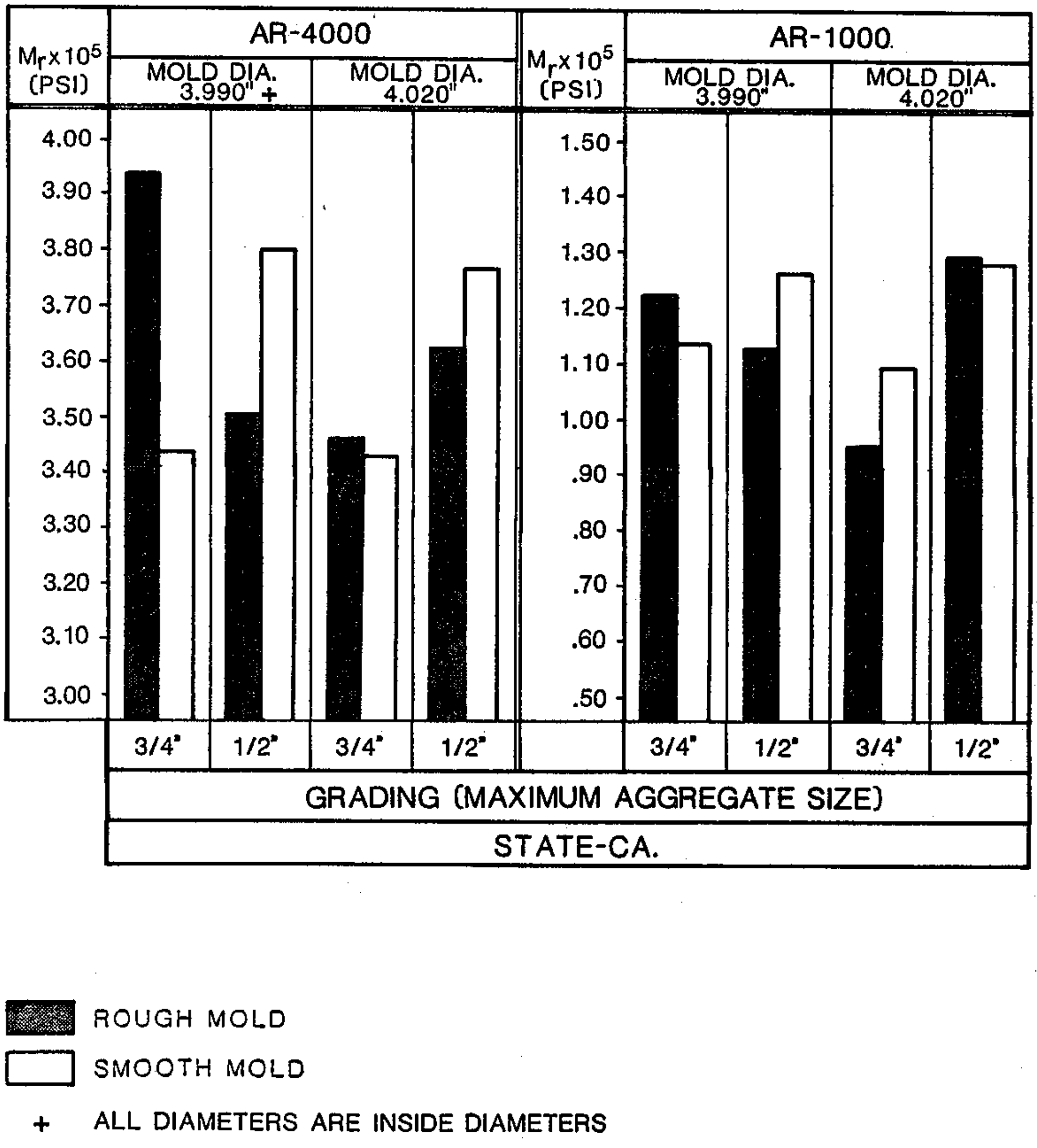
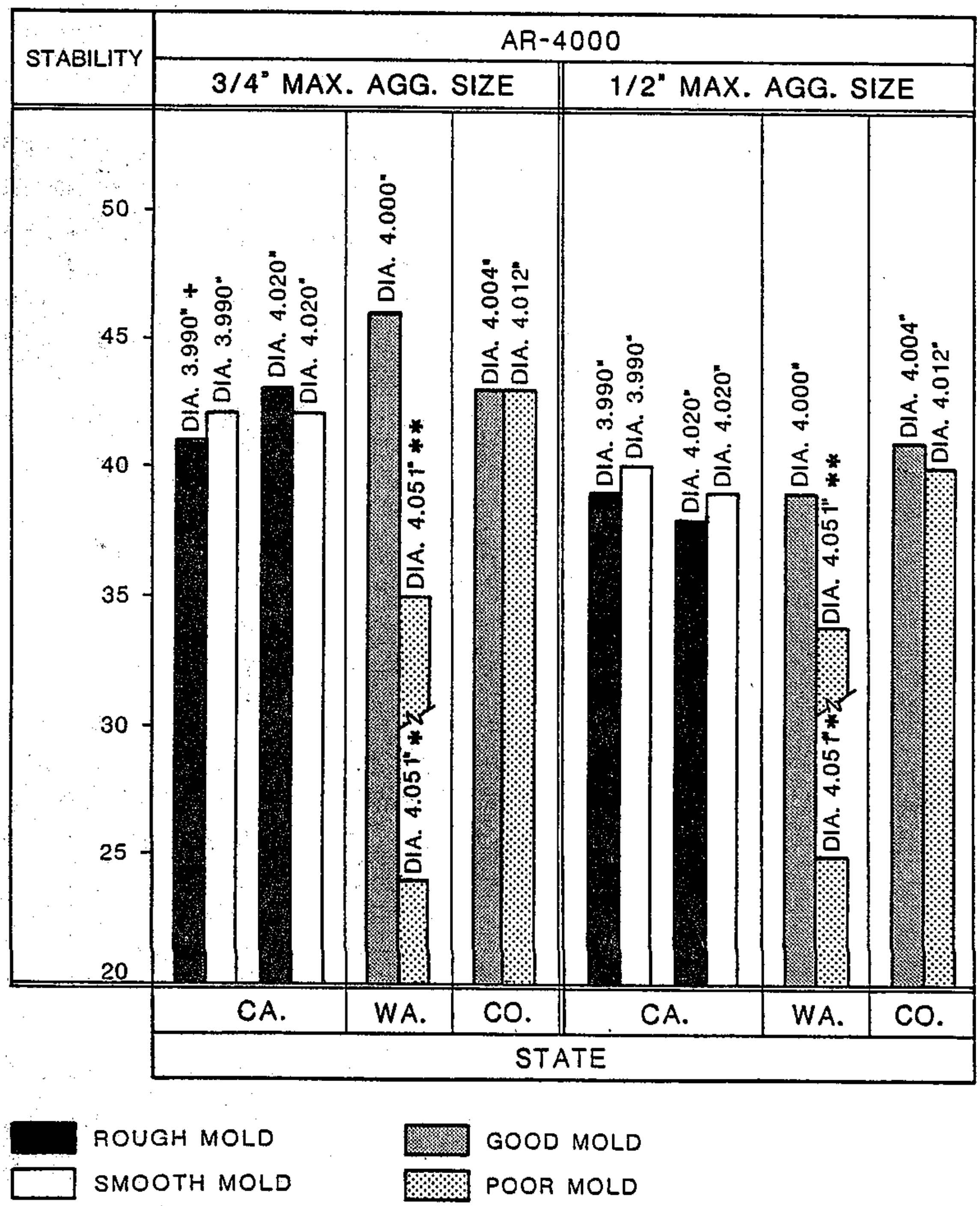


FIGURE 4

DATA COMPARISON BETWEEN STATES - STABILITY

CALIFORNIA TEST 366



\+ ALL DIAMETERS ARE AVERAGE INSIDE DIAMETERS

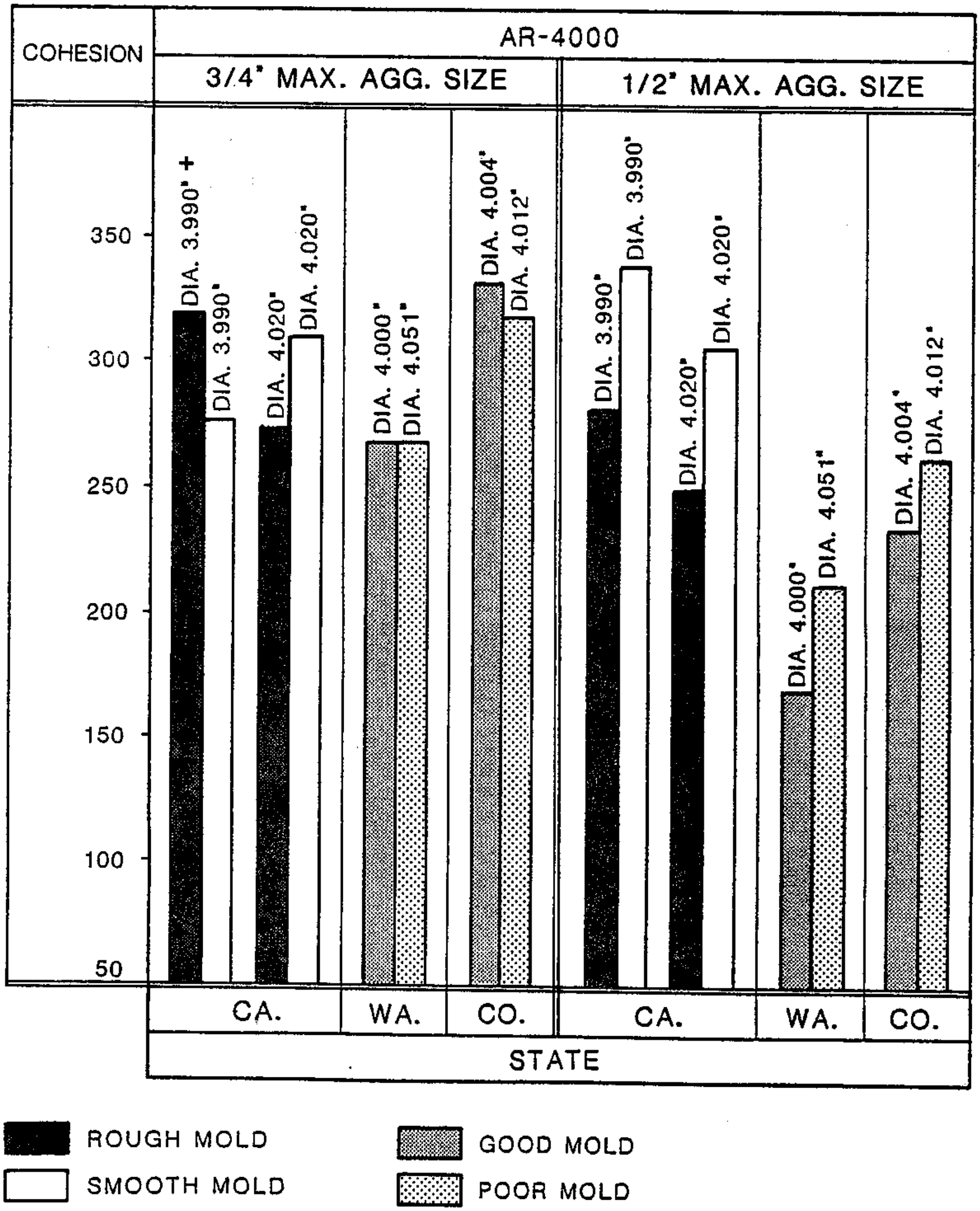
* TESTED IN HVEEM STABILOMETER L-1

** TESTED IN HVEEM STABILOMETER L-6

FIGURE 5

DATA COMPARISON BETWEEN STATES - COHESION

CALIFORNIA TEST 306



\+ ALL DIAMETERS ARE AVERAGE INSIDE DIAMETERS

FIGURE 6

DATA COMPARISON BETWEEN STATES - M_r

CHEVRON METHOD

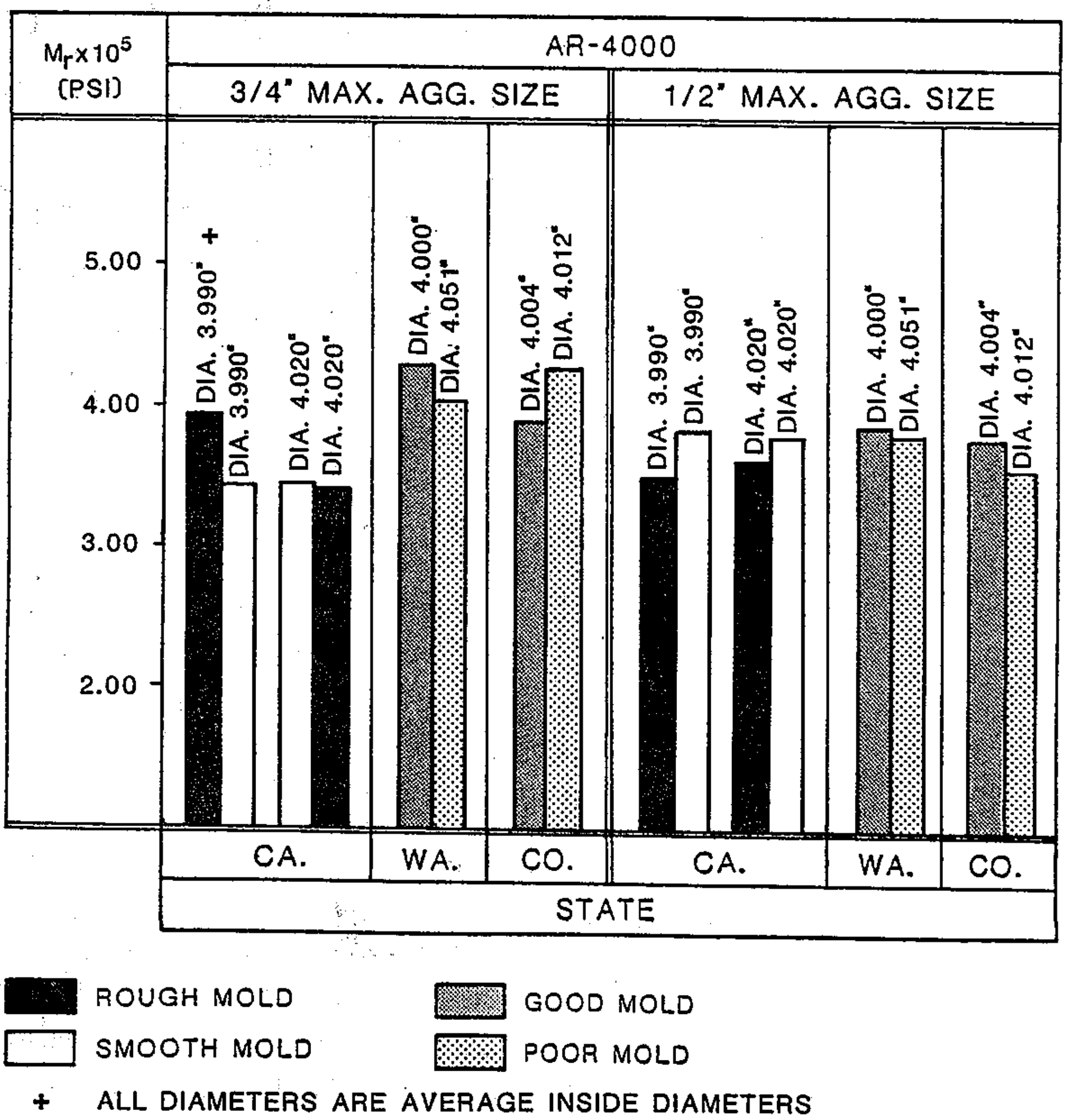


FIGURE 7

a. Good Mold

The "good" mold, as classified by Washington, had a surface texture of 70, and an average inside diameter of 4.000 inches. The cohesion and M_r values were comparable to the data obtained with the California and Colorado test molds, except for the lower cohesion value in the Washington mold. Since this did not show up in the 3/4 inch mix, it probably cannot be attributed to the mold. Also, the stability value was slightly higher for the 3/4-inch mix. It was felt that this properly reflected mix ingredients and did not relate to the fabrication mold. This assumption was made because the data for the 1/2-inch mix did not show the same trend.

b. Poor Mold

The "poor" mold, as classified by Washington, had a surface texture of 125 and an average inside diameter of 4.051 inches. The surface texture of this mold, overall, was quite smooth and similar to the mold from this state designated as "good". However, a number of small pitts in the surface raised the value for texture from 70 to 125. Although values for cohesion and M_r of test specimens prepared in this mold were comparable to data obtained in the California and Colorado molds, the stabilometer values were significantly lower (Figure 5). It was assumed that this was attributed directly to the larger diameter of the mold which produced specimens that were larger in diameter than the stabilometer throat (stabilometer used was L-1 and had a throat diameter of 4.045 inches). Subsequently, when inserting the test specimens into the stabilometer, the sides were disturbed and the integrity of the specimens was destroyed, thereby giving a lower value.

To verify this assumption, additional tests were performed using a stabilometer with a larger throat diameter (stabilometer L-6, with a throat diameter of 4.052 inches) and higher values were obtained (Figure 5).

3. Colorado Molds

The molds from this state had average diameters of 4.004 and 4.012 inches (the 4.012 inch mold was classified as the "poor" mold by Colorado). The surface texture measured for both molds was 40. Both diameter and texture of these molds were within the extremes of the machined molds, and it is felt that no testing error should be the result of using either of these molds. This is verified by the data in Figures 5, 6, and 7 which indicates that the stabilometer, cohesion, and M_r values for specimens prepared in these molds were comparable with specimens prepared in the California molds and in the "good" mold for the State of Washington.

This data would indicate that some problem other than the mold characteristics must be present in Colorado.

G. Summary

The results of this study indicate that mold surface texture has an insignificant effect on test values. This is also true for inside diameter if this diameter is smaller than the diameter of the throat of the stabilometer used. But, since many molds were not tested from different states, it may be that molds with pits or scars, if prolific and deep, could conceivably create a problem with fabrication of specimens. However, to specify the amount or degree permissible would be difficult. Therefore, the following suggestions are presented to help alleviate some of those concerns:

1. Specify mold dimensions and inside surface texture.

2. Discard molds when the diameter is 4.020 inches or greater.

3. Maintain a set of three standard molds to be used only for calibration work. Should any routine mold become questionable, use these three standard molds, set aside for exclusive use as a calibration device, to check for correlation of data. From Caltrans' experience ± 3 points would be adequate for acceptable correlation of stability data.

The following specifications for new molds are recommended:

- molds shall be constructed of stainless steel
- inside diameter shall be 4.000 ± 0.010 inches
- outside diameter shall be 4.490 ± 0.010 inches
- height shall be 5.000 ± 0.010 inches
- inside surface texture using the MMP scale (Micro Metrocal Profilometer) shall be 270 maximum - see note below
- roundness - any two measurements of the inside diameter shall not vary by more than ± 0.005 inches.

Note: The inside texture or roughness is obtained by smooth machining the inside diameter to 4.000 ± 0.010 inches, followed by a final operation with a boring tool ground flat to measure 0.001 to 0.003 inches across the tip of the tool. The depth of cut used should be 0.002 inches with 0.010 inch feed using sulfur based coolant.

APPENDIX

Tabulated Test Data

TABLE A-1

State of Washington (3/4" Med. Gradation)

Mold			* Test No.	Asph. AR Grade	Test Data			
Class	Texture	Diameter **			Stab.	Coh.	S.G.	M_R
Good	70	A 4.000	1	4000	45	201	2.43	-
"	"	B 4.000	2	"	47	326	2.45	-
"	"		3	"	46	279	2.43	-
"	"		Av.	"	46	269	2.44	-
"	"		4	"	47	275	2.44	4.28×10^5
Poor	125	A 4.054	1	4000	25	233	2.43	-
"	"	B 4.048	2	"	23	330	2.44	-
"	"		3	"	25	245	2.44	-
"	"		Av.	"	24	269	2.44	-
"	"		4	"	30	267	2.44	4.03×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

** Measurement A taken 90 degrees to measurement B.

TABLE A-2

State of Washington (1/2" Med. Gradation)

Mold			* Test No.	Asph. AR Grade	Test Data			
Class	Texture	Diameter **			Stab.	Coh.	S.G.	M_R
Good	70	A 4.000	1	4000	38	164	2.37	-
"	"	B 4.000	2	"	39	126	2.35	-
"	"		3	"	39	221	2.38	-
"	"		Av.	"	39	170	2.37	-
"	"		4	"	38	208	2.38	3.82×10^5
Poor	125	A 4.054	1	4000	27	183	2.37	-
"	"	B 4.048	2	"	24	220	2.39	-
"	"		3	"	23	232	2.37	-
"	"		Av.	"	25	212	2.38	-
"	"		4	"	27	316	2.39	3.76×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

** Measurement A taken 90 degrees to measurement B.

TABLE A-3

State of Colorado (3/4" Med. Gradation)

Mold			*	Asph.	Test Data			
Class	Texture	Diameter **	Test No.	AR Grade	Stab.	Coh.	S.G.	M_R
Good	40	A 4.004	1	4000	44	392	2.45	–
"	"	B 4.004	2	"	43	286	2.44	–
"	"		3	"	43	317	2.46	–
"	"		Av.	"	43	332	2.45	–
"	"		4	"	39	260	2.42	3.89×10^5
Poor	40	A 4.012	1	4000	45	308	2.45	–
"	"	B 4.013	2	"	42	281	2.44	–
"	"		3	"	42	363	2.45	–
"	"		Av.	"	43	317	2.45	–
"	"		4	"	43	336	2.44	4.23×10^5

*Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

** Measurement A taken 90 degrees to measurement B.

TABLE A-4

State of Colorado (1/2" Med. Gradation)

Mold			* Test No.	Asph. AR Grade	Test Data			
Class	Texture	Diameter **			Stab.	Coh.	S.G.	M_R
Good	40	A 4.004	1	4000	43	193	2.39	–
"	"	B 4.004	2	"	42	270	2.39	–
"	"		3	"	38	244	2.39	–
"	"		Av.	"	41	236	2.39	–
"	"		4	"	37	180	2.39	3.75×10^5
Poor	40	A 4.012	1	4000	41	282	2.40	–
"	"	B 4.013	2	"	41	256	2.39	–
"	"		3	"	39	253	2.39	–
"	"		Av.	"	40	264	2.39	–
"	"		4	"	34	145	2.36	3.54×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

** Measurement A taken 90 degrees to measurement B.

TABLE A-5

Series 1 (3/4" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	3.990	1	4000	42	354	2.44	-
" 263	"	2	4000	38	281	2.44	-
"	"	3	4000	44	323	2.43	-
"	"	Av.	4000	41	319	2.44	-
"	"	4	4000	46	321	2.43	3.93×10^5
Smooth	3.990	1	4000	39	265	2.45	-
" 18	"	2	4000	43	363	2.46	-
"	"	3	4000	43	199	2.44	-
"	"	Av.	4000	42	276	2.45	-
"	"	4	4000	40	272	2.43	3.44×10^5

*Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-6

Series 1A (3/4" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	4.020	1	4000	40	249	2.43	-
" 260	"	2	4000	47	343	2.43	-
"	"	3	4000	43	229	2.43	-
"	"	Av.	4000	43	274	2.43	-
"	"	4	4000	41	190	2.43	3.45×10^5
Smooth	4.020	1	4000	40	386	2.44	-
" 25	"	2	4000	41	308	2.46	-
"	"	3	4000	44	240	2.45	-
"	"	Av.	4000	42	311	2.45	-
"	"	4	4000	41	328	2.45	3.42×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-7

Series 2 (1/2" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	3.990	1	4000	39	213	2.40	-
" 263	"	2	4000	39	355	2.39	-
"	"	3	4000	40	279	2.41	-
"	"	Av.	4000	39	282	2.40	-
"	"	4	4000	40	255	2.41	3.50×10^5
Smooth	3.990	1	4000	39	248	2.40	-
" 18	"	2	4000	40	429	2.41	-
"	"	3	4000	40	331	2.42	-
"	"	Av.	4000	40	336	2.41	-
"	"	4	4000	39	342	2.42	3.80×10^5

Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-8

Series 2A (1/2" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	4.020	1	4000	35	225	2.40	-
" 260	"	2	4000	41	290	2.40	-
"	"	3	4000	38	234	2.39	-
"	"	Av.	4000	38	250	2.40	-
"	"	4	4000	41	233	2.40	3.61×10^5
Smooth	4.020	1	4000	39	288	2.40	-
" 25	"	2	4000	39	409	2.41	-
"	"	3	4000	39	217	2.40	-
"	"	Av.	4000	39	305	2.40	-
"	"	4	4000	39	332	2.40	3.76×10^5

*Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-9

Series 1 (3/4" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	3.990	1	1000	42	108	2.43	-
" 263	"	2	1000	40	119	2.44	-
"	"	3	1000	41	195	2.46	-
"	"	Av.	1000	41	141	2.44	-
"	"	4	1000	43	147	2.45	1.22×10^5
Smooth	3.990	1	1000	40	69	2.43	-
" 18	"	2	1000	40	90	2.44	-
"	"	3	1000	36	77	2.43	-
"	"	Av.	1000	39	79	2.43	-
"	"	4	1000	39	76	2.42	1.14×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-10

Series 1A (3/4" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	4.020	1	1000	41	138	2.43	-
" 260	"	2	1000	40	124	2.46	-
"	"	3	1000	38	100	2.43	-
"	"	Av.	1000	40	121	2.44	-
"	"	4	1000	36	74	2.42	0.96×10^5
Smooth	4.020	1	1000	39	161	2.46	-
" 25	"	2	1000	41	157	2.46	-
"	"	3	1000	40	143	2.44	-
"	"	Av.	1000	40	154	2.45	-
"	"	4	1000	35	87	2.45	1.09×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-11

Series 2 (1/2" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	3.990	1	1000	36	62	2.38	-
" 263	"	2	1000	37	115	2.41	-
"	"	3	1000	34	90	2.42	-
"	"	Av.	1000	36	89	2.40	-
"	"	4	1000	38	134	2.42	1.12×10^5
Smooth	3.990	1	1000	39	98	2.41	-
" 18	"	2	1000	36	105	2.41	-
"	"	3	1000	38	117	2.40	-
"	"	Av.	1000	38	107	2.41	-
"	"	4	1000	35	226	2.43	1.27×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.

TABLE A-12

Series 2A (1/2" Med Gradation)

Mold		* Test	Asph.	Test Data			
Texture	Diameter	No.	AR Grade	Stab.	Coh.	S.G.	M_R
Rough	4.020	1	1000	37	76	2.41	-
" 260	"	2	1000	34	67	2.40	-
"	"	3	1000	37	73	2.41	-
"	"	Av.	1000	36	72	2.41	-
"	"	4	1000	40	146	2.41	1.29×10^5
Smooth	4.020	1	1000	37	55	2.40	-
" 25	"	2	1000	40	102	2.41	-
"	"	3	1000	36	114	2.41	-
"	"	Av.	1000	38	90	2.41	-
"	"	4	1000	35	144	2.42	1.28×10^5

* Test Nos. 1, 2 & 3 confine the specimen in the mold until the moment the stability test is run. Test No. 4, after the M_R test, is heated unconfined for the stabilometer test.